Using TOA fluxes by cloud type to evaluate the CanAM4

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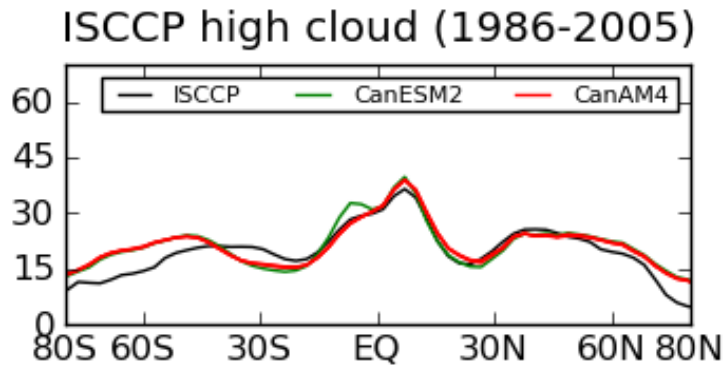
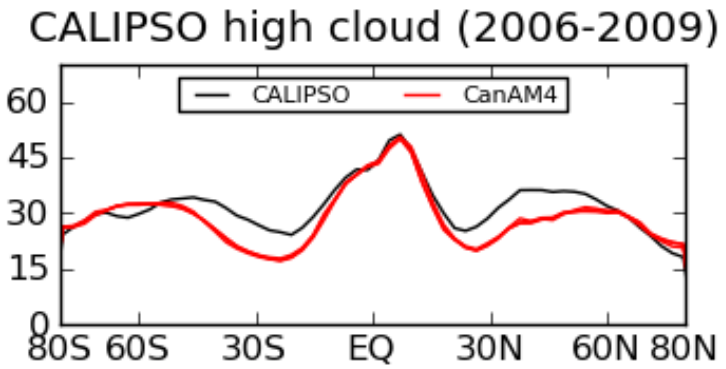
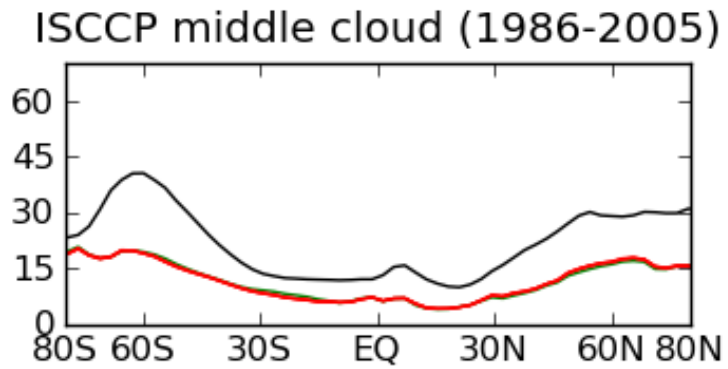
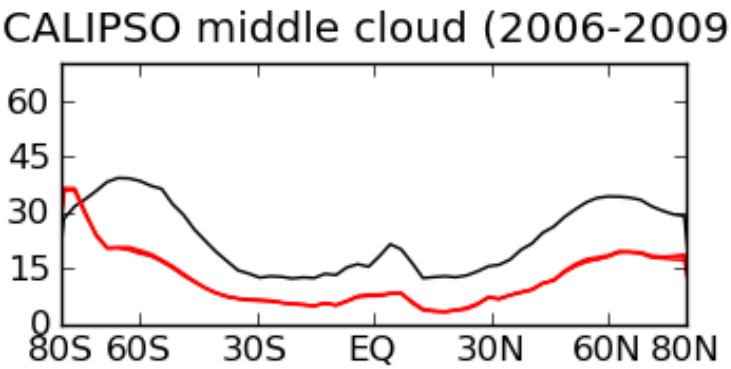
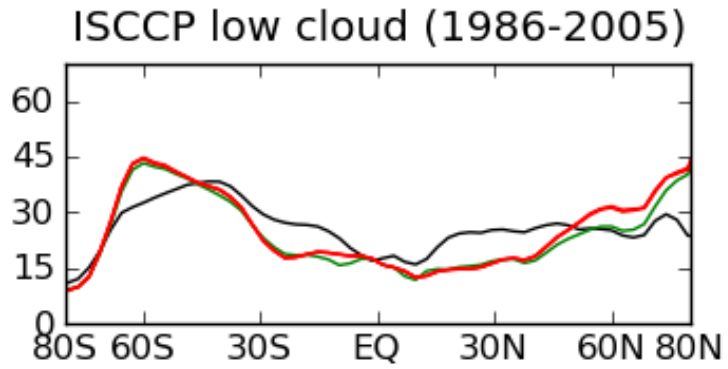
Zonal annual mean cloud fractions

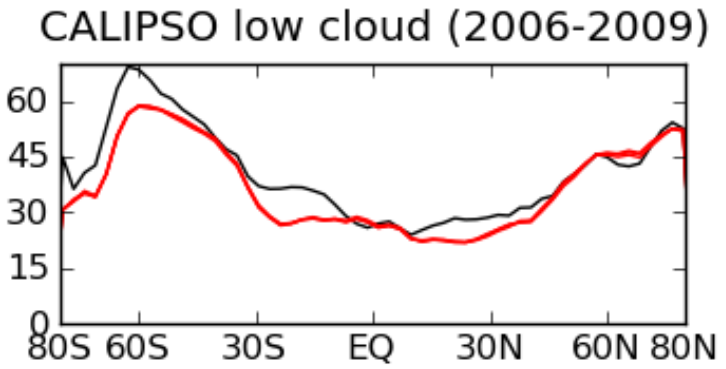








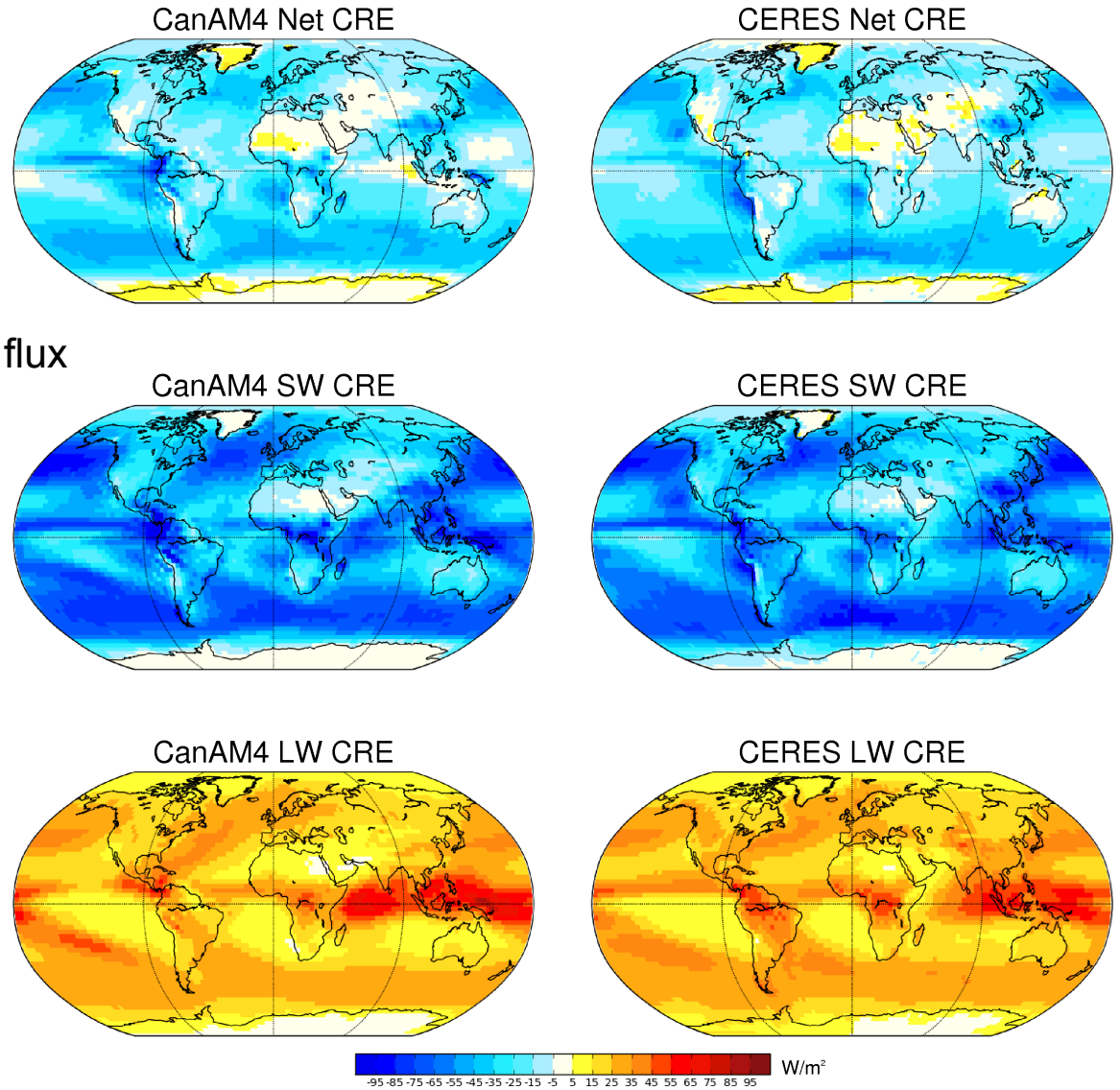




Top of atmos. cloud radiative effect (CRE) (2000-2009)

CRE=clear-sky flux – all-sky flux

Dataset: CERES EBAF

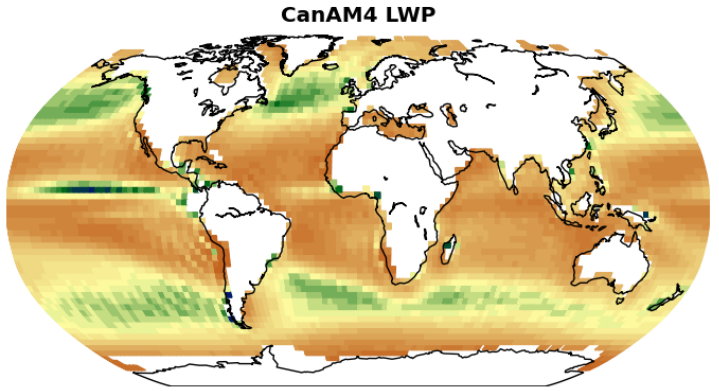


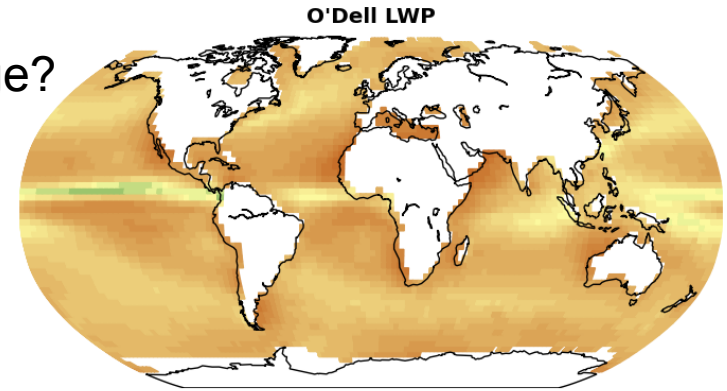
-95 W/m^2 95 W/m^2

Is TOA cloud rad. effect consistent with liq. water path?

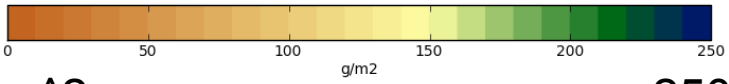
Annual mean liquid water path averaged over 1988-2007.

CanAM4 is much larger in mid-lat storm tracks. Why isn't reflected solar too large?





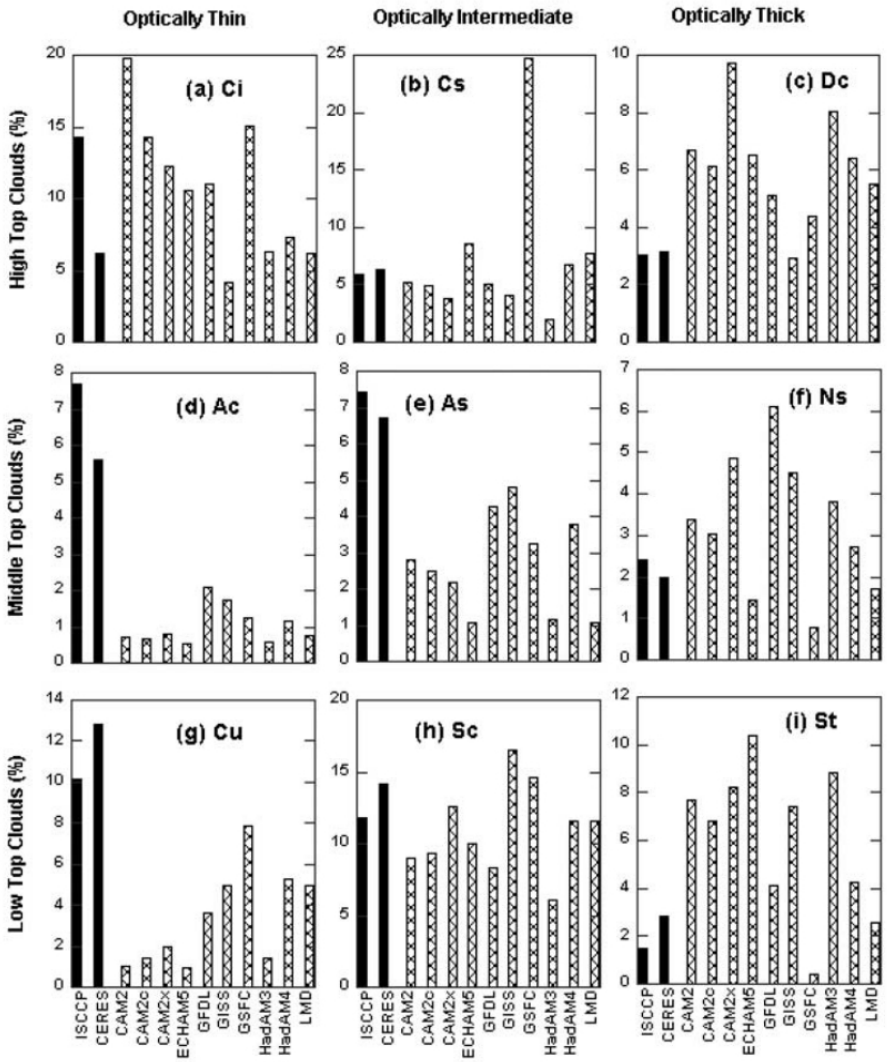
Dataset: O'Dell, *J. Climate*, 2008



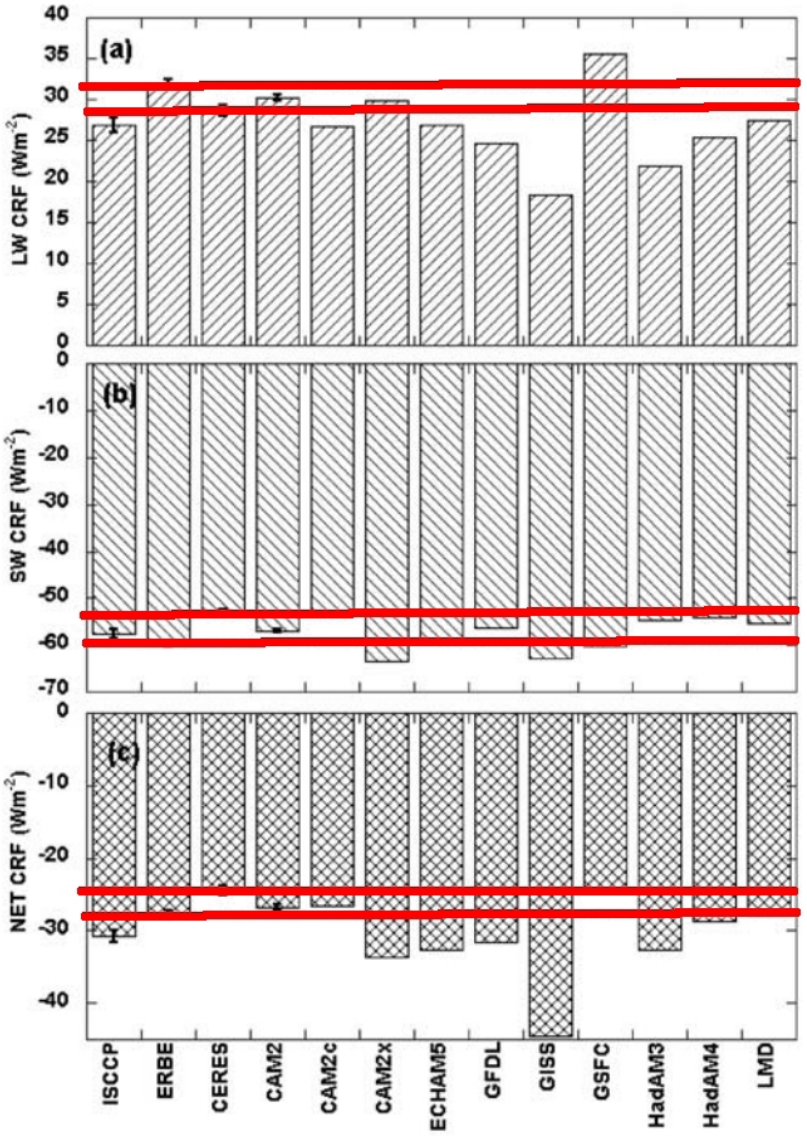
0 g/m^2 250 g/m^2

Compensating biases in clouds

Zhang et. al., 2005; 60S-60N
DJF, 2001-2002



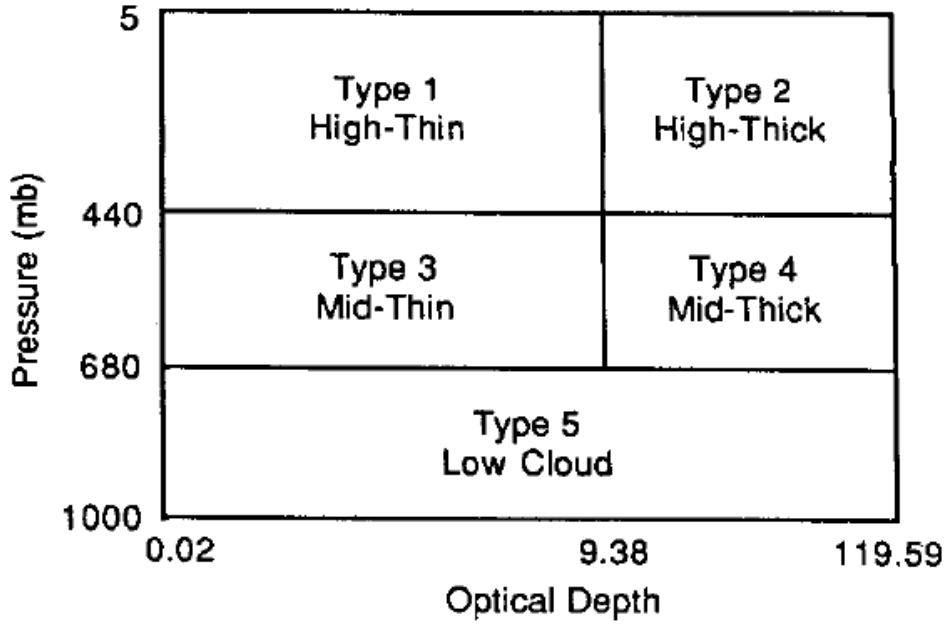
$CRE=A(F_{clr}-F_{cld})$



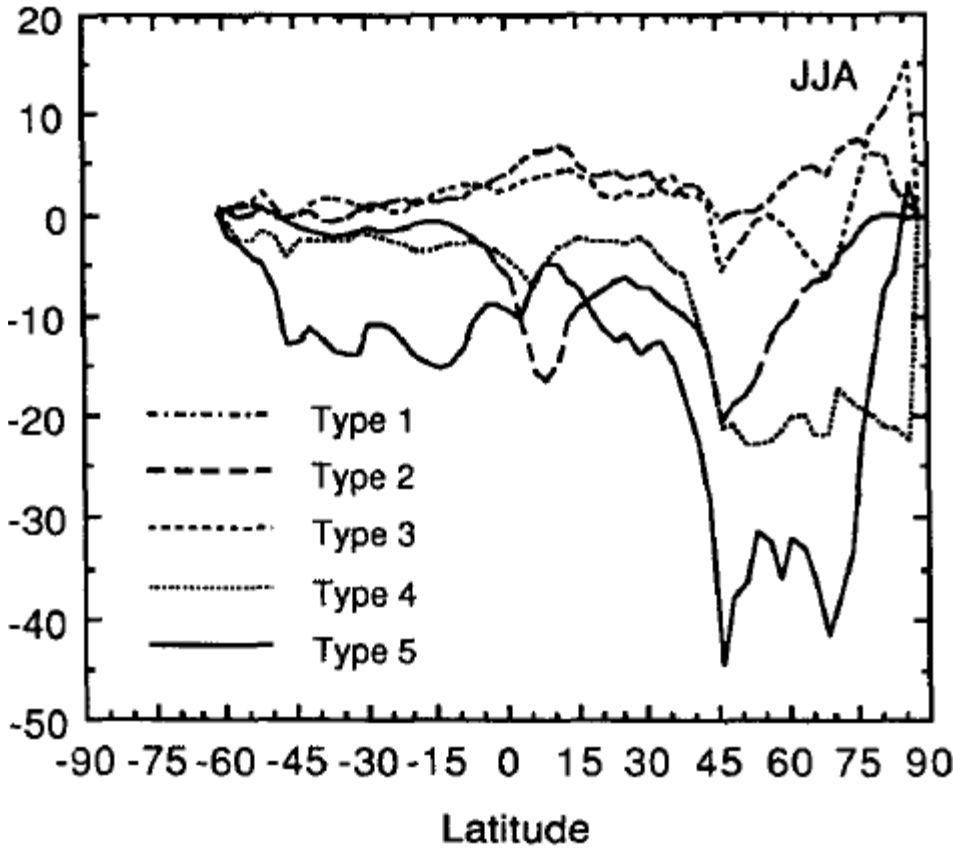
Radiative effects by cloud type

Hartmann et. al., 1992 => ERBE and ISCCP

"We believe it will be important to verify that the net cloud radiative forcing by individual cloud types *(simulated in GCMs)* is as observed, as well as to verify that the total cloud forcing is realisitic."

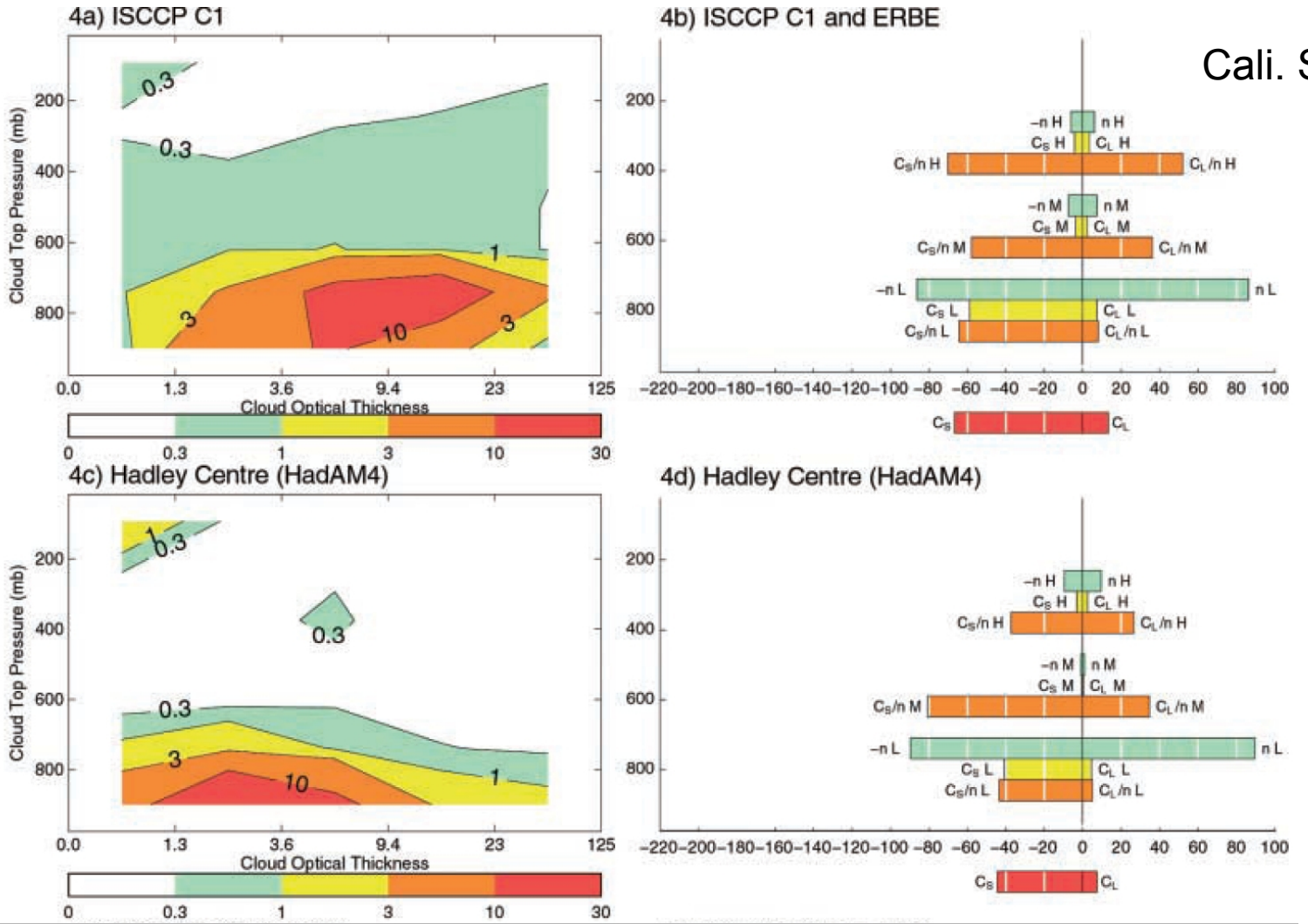


Net cloud forcing



Radiative effects by cloud type

Hartmann et. al., 1992 => ERBE and ISCCP
Chen et. al., 2000 => ISCCP + radiative transfer calculations
Webb et. al., 2001 => daily ERBE and ISCCP (July 98)



Cali. Sc region

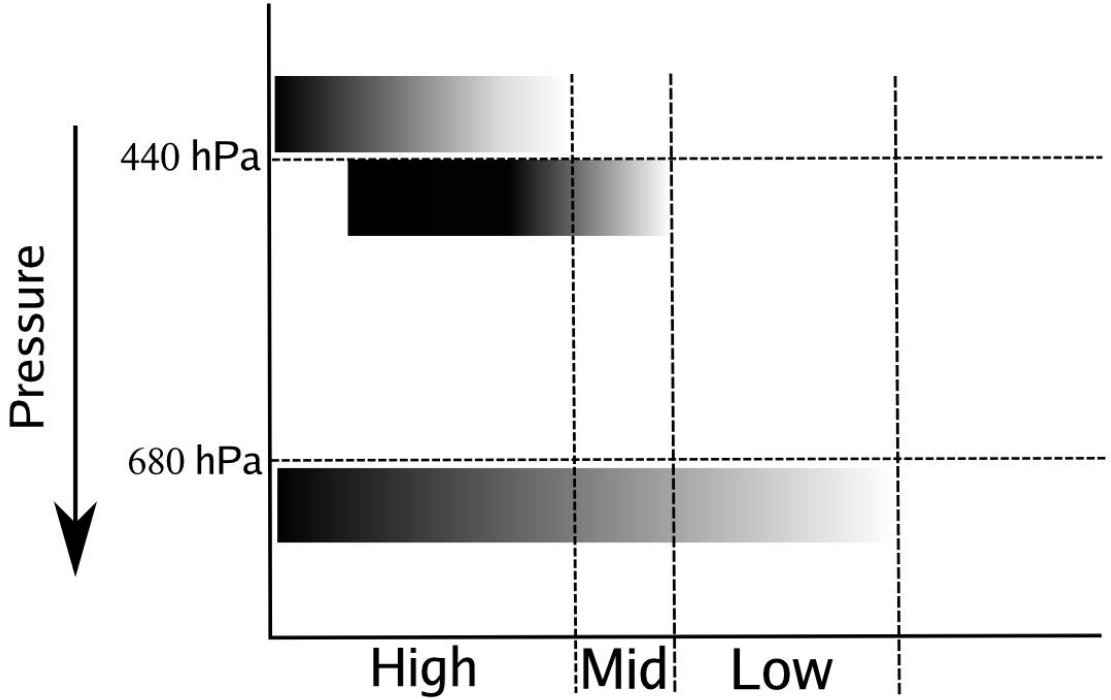
Radiative effects by cloud type: CERES and MODIS

Clear-sky Cloudy-sky

$$\langle F \rangle = (1 - A_c) \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(j) + A_c \left(\frac{1}{N_{cld}}\right) \sum_{i=1}^{i=N_{cld}} \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(i,j)$$

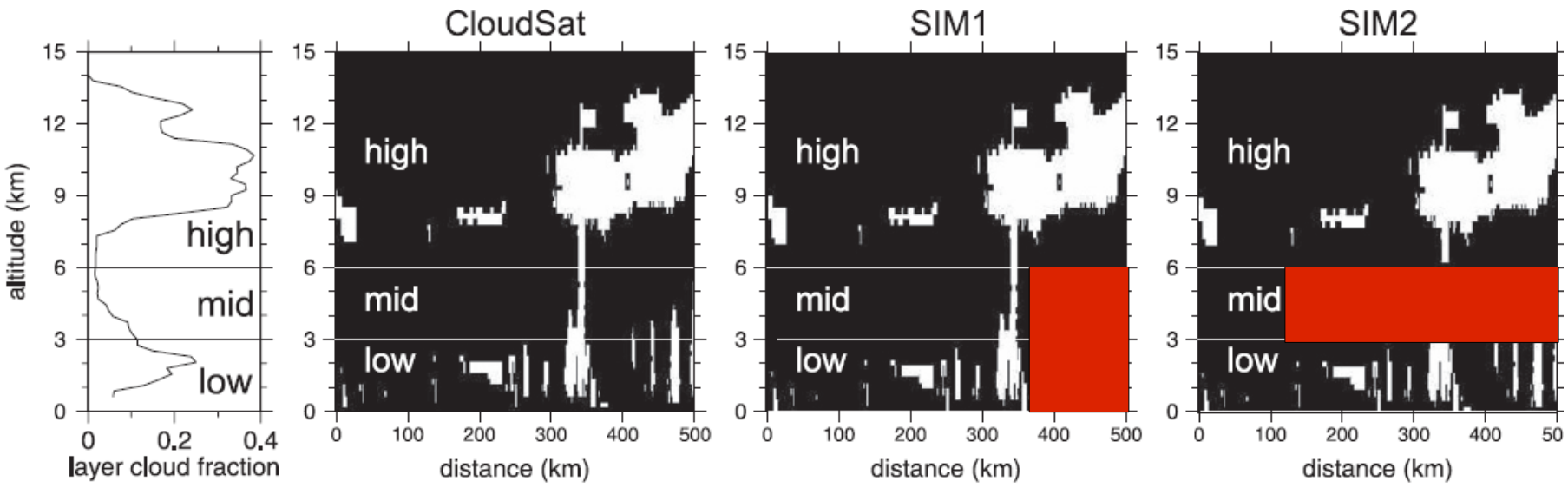
Variables observable from CERES+MODIS

$$F_{cld} = \sum_{m=1}^{m=M} A_{c,m} F_{cld,m}; F_{cld,m} = \frac{1}{N_{cld,m}} \sum_{i=1,i}^{N_{cld,m}} \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(i,j)$$



Case of M=3 with vertical boundaries matching ISCCP

An example from a CloudSat/CALIPSO cross-section



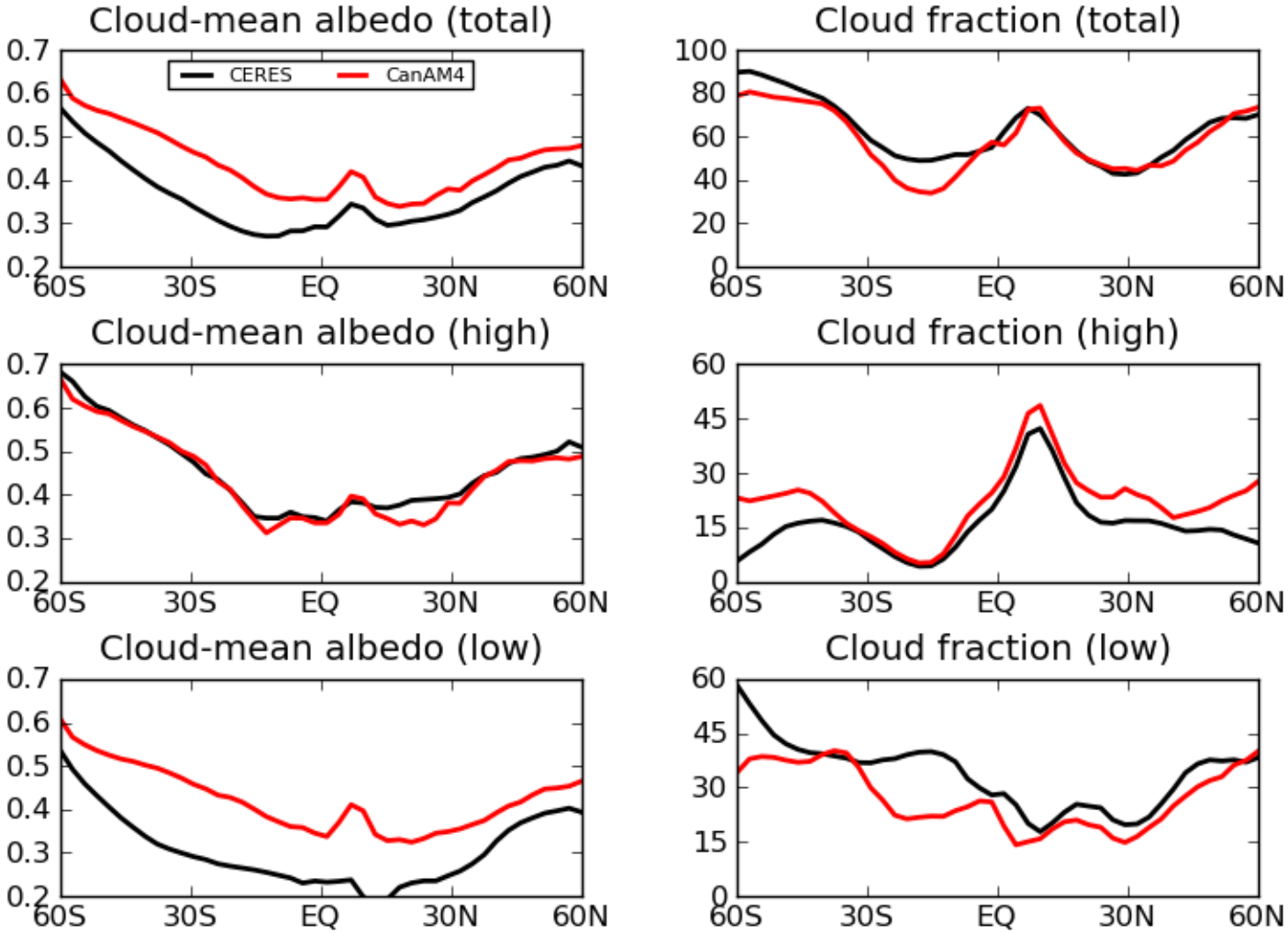
$$\nu = \left(\frac{\langle\tau\rangle}{\sigma_\tau}\right)^2$$

layer	A_i	$\langle\tau\rangle$	ν	α_p	A_i	$\langle\tau\rangle$	ν	α_p	A_i	$\langle\tau\rangle$	ν	α_p
high	**0.60**	**20.9**	**0.31**	**0.46**	0.60	13.5	0.20	0.39	0.60	16.1	0.38	0.46
mid	**0.0**	**0.0**	**0.0**	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
low	**0.07**	**22.6**	**1.04**	**0.65**	0.07	22.6	1.04	0.65	0.07	22.6	1.04	0.65
all	**0.67**	**21.1**	**0.34**	**0.48**	0.67	14.5	0.24	0.42	0.67	16.8	0.42	0.48

Complete dataset (cloud props + radiation) give more information
Uncertainity about underlying clouds due to passive observations
- active observations are needed for profile info

Compensating biases in clouds: CanAM4 Results

July 2001-2005 60°S-60°N



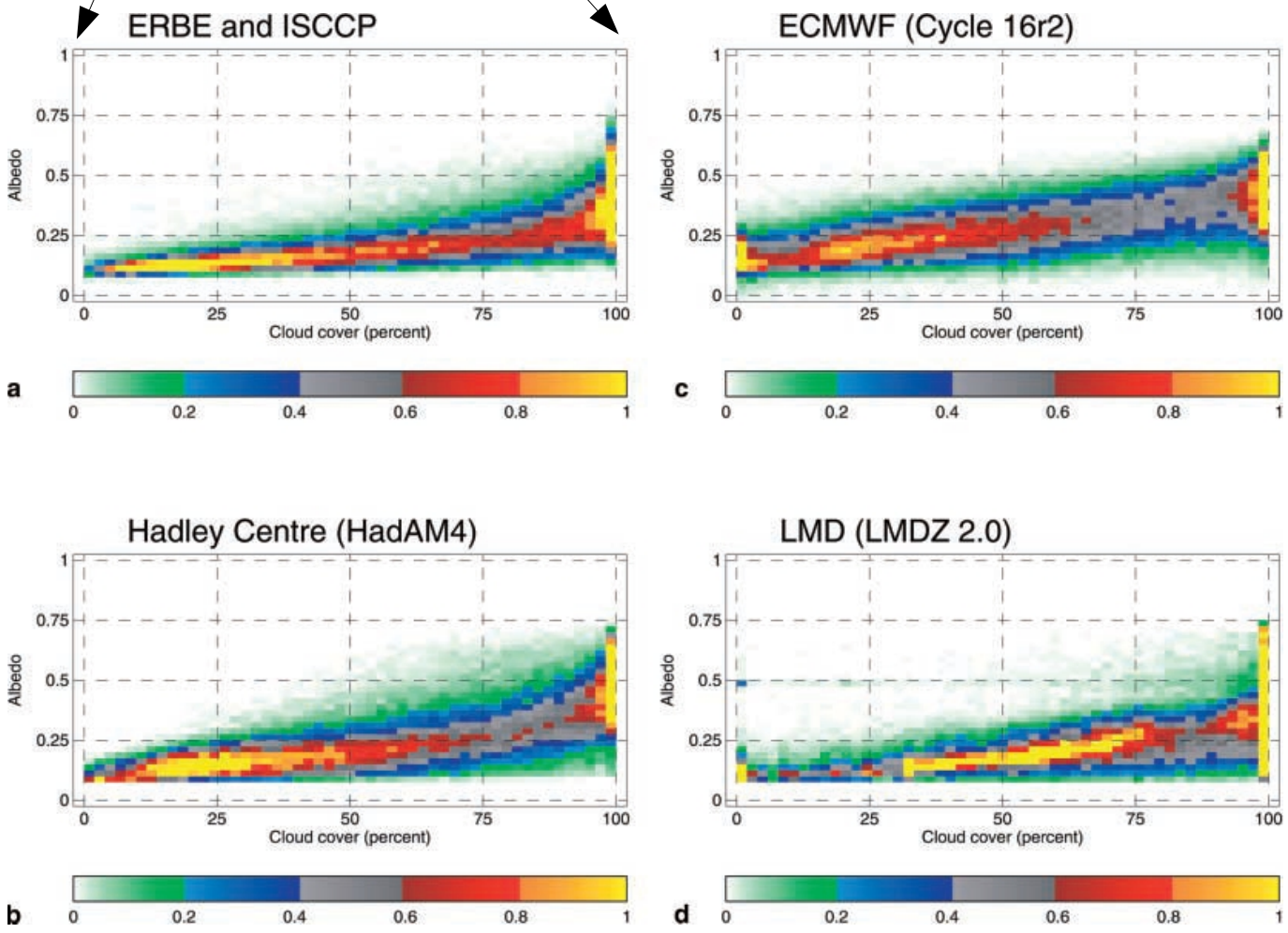
Cole et. al., *J. Climate*, 2011

Relation between albedo and cloud fraction (July 1998)

All clr sky

All cld sky

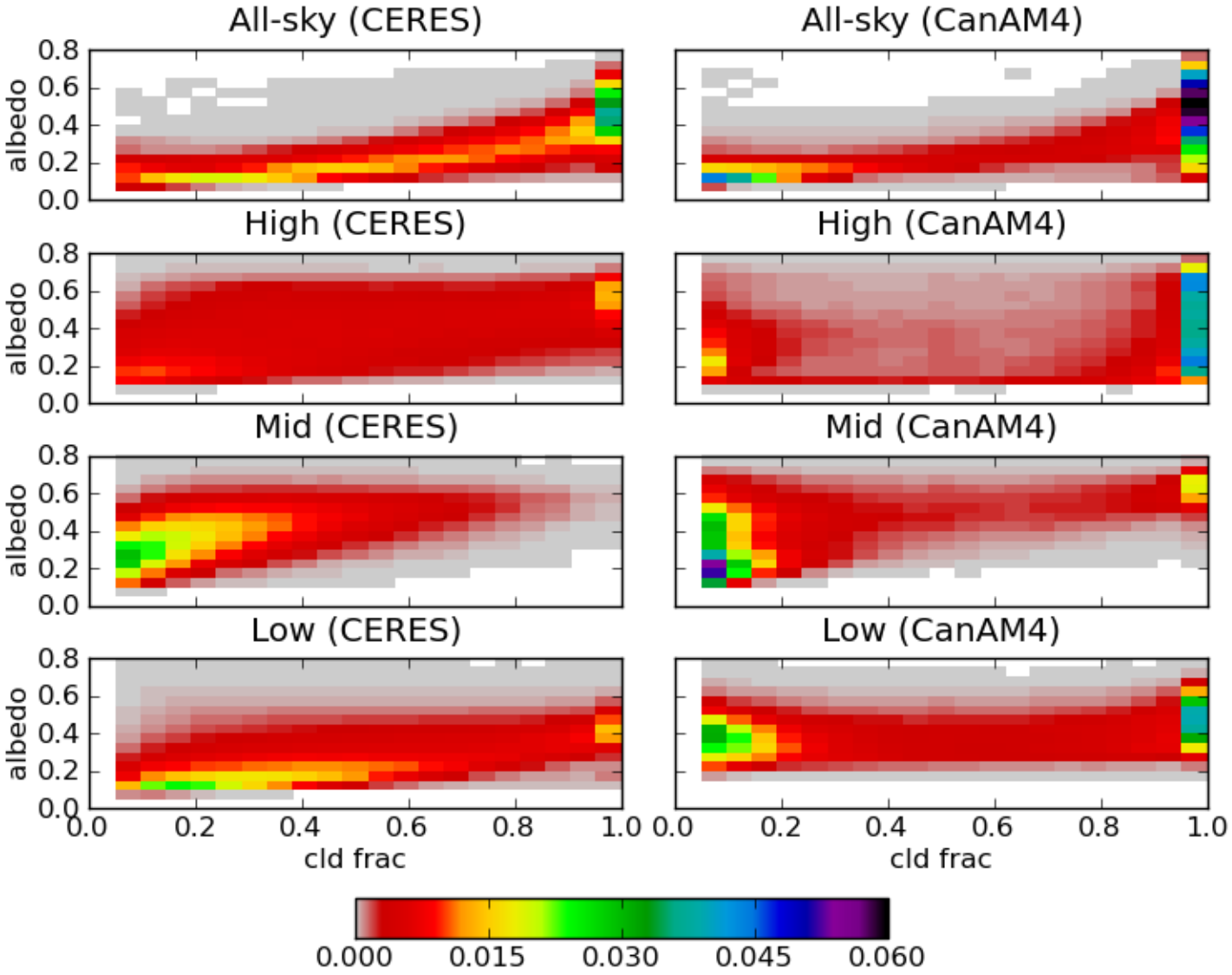
$$\alpha = (1 - A_c)\alpha_{clr} + A_c\alpha_{cld}$$



Webb et. al., 2001

Daily mean variations in albedo and cloud fraction

July 2001-2005 60°S-60°N



Summary

- Time mean cloud and radiation properties are similar to observations
  - Use of simulators aid in comparisions
  - Several of the biases are known and some are similar to other models

- Supplement passive cloud properties with TOA radiative fluxes by cloud-type
  - There are time-mean biases that are consistent with our expectations
  - Time means are realized in rather different ways wrt observations

- Fuller evaluation of CanAM4 using the new flux by cloud type dataset